REDUCTION OF FORWARDING NODES TO REDUCE EFFECT OF BROADCAST STORM PROBLEM USING NETWORK CODING

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By

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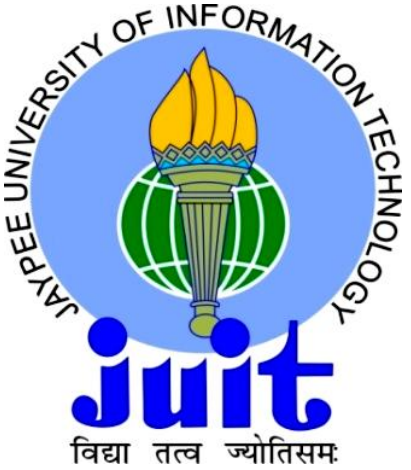

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ABSTRACT

The Wireless medium is creating numerous fortuities for nodes to get packets when they are not the anticipated beneficiary. MANET is such a sort of specially appointed Network. Message broadcasting is a basic function in wireless Ad-hoc network in which a node passes on a message to all neighbors thus causing redundant broadcast which is called as Broadcast storm Problem in which every node will be obligated to re-broadcast the data packet every time it gets the data packet thus causing redundancy. In this way, the no. of forwarding nodes is utilized as the cost criterion for propagation.

In addition to forwarding packets, routers mix (i.e., code) packets from different sources to increase the information content of each transmission by XORing two or more packets. This design is rooted in the theory of network coding. Prior work on network coding focuses on multicast traffic. This thesis aims to bridge theory with practice by addressing the common issues faced in the integration of network coding in the current network stack.

Proposed algorithm along with network coding concept uses 1-Hop nodes to cover entire 2-Hop nodes utilizing 2-hop region information to decrease repetitive communicates. Simulation results of applying this algorithm demonstrate performance improvements. Now a days the scientists are acquainting the idea of Network coding to neighbour topology aware protocols that beats the excess number of broadcast by XOR of data packets. We have made an endeavor to seek out the network coding gain. We've shown simulation, implementation and breakdown of result in various circumstances.

Another proposed algorithm uses bit addresses to where every node is distinguished by bit value '1' in an address bit vector. Distinguishing packets and processing the network coding of packets can be effectively done utilizing address bit vectors. This algorithm also acknowledges redundancy with total no. of coded packets sent with respect to actual no. of nodes present in the system.

To carry out work in similar direction, Network Coding Algorithm also on integrating with the AODV protocol, provides energy proficient system as compared to the old Network coding scheme since less no. of average transmissions are required per node. The enhancement in the performance of the proposed AODV integrated Network coding scheme over the traditional Network coding scheme increases with increase in density. Hence a basic alteration of discovering a reduced subgraph from the first original subgraph utilizing AODV routing scheme can enhance the execution of Network Coding to an awesome degree.

To achieve lesser redundancy in terms of achieving less no. of forwarding nodes for retransmission uses the concept of degree of incoming traffic and outgoing traffic of a node along with link bandwidth when integrated with probabilistic based Network coding, provides result to awesome degree. SET Partition theory based algorithm when integrated with Network Coding approach distinguishes and comprises nodes based on the fact of bundles of different network coded reduces the No. of Forwarding nodes for retransmission in contrast to actual no. of nodes.

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1. INTRODUCTION

Wireless networks are indispensable; they provide the means for mobility, city-wide Internet connectivity, distributed sensing, and outdoor computing. Current wireless implementations, however, suffer from a severe throughput limitation and do not scale to dense large networks. Traditional routing chooses the nexthop before transmitting a packet; but, when link quality is poor, the probability the chosen nexthop receives the packet is low.

1.1 Broadcast storm Problem

Message broadcasting is a basic function in wireless Ad-hoc network in which a node passes on a message "m" to all neighbors thus causing redundant broadcast which is called as Broadcast storm Problem in which every node will be obligated to re-broadcast the data packet every time it gets the data packet [1][7]. In MANETs, flooding of messages will bring about numerous repetitive correspondences.

Figure 1.1 demonstrates a topology of a MANET. At the point, node "u" broadcasts a packet, node "v" and node "w" receives the packet, At that point, node "v" and node "w" will rebroadcast the packet to each other.

Misleadingly the two communications may bring thoughtful broadcast storm problem, where these redundant packet cause collision & contention.

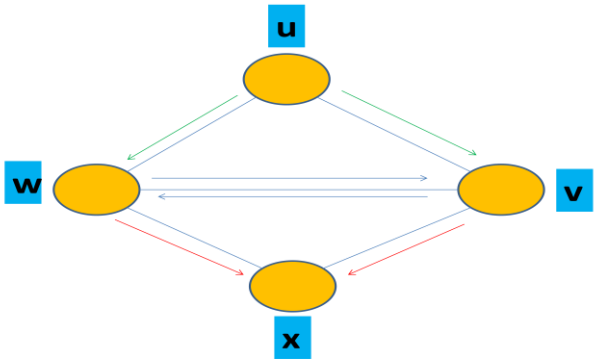

Figure 1.1: Flooding in MANET

In figure 1.2, Bits m_1 and m_2 need to be transferred to both receivers R_1 and R_2. Every link transmits only a bit. Message m_1 and m_2 can be received either on the right or on the left side.

1.2 Network Coding

Solution: Compute XOR (i.e. Apply network coding) in the middle link and both sides get m_1 and m_2. Table 1.1 clearly demonstrates this. Intermediate nodes will further send packets which are XORed of previous received bits [2].

Table 1.1
XOR operation between m_1 and m_2

m_2	m_1	$m_3 = m_2 \oplus m_1$	$m_2 = m_3 \oplus m_1$	$m_1 = m_3 \oplus m_2$
1	1	0	1	1
0	1	1	0	1
1	0	1	1	0
0	0	0	0	0

The task is to pick out tiny set of forwarding nodes within the deficiency of global network information. The researchers have done substantial work to seek out Connecting Dominating Set two ways, namely 2-hop & 1-hop neighbor information [4] [5].

Many broadcast algorithms besides blind flooding have been proposed [10], [11], [12], [13], [14], [15], [16]. Typical global [17] [18] and quasi-global [19] broadcast protocols use either global or partial global information to consensus a small forward node set. To reduce the effect of the broadcast storm problem, we should prevent redundant retransmits of the broadcast packet and differentiate the timing of retransmits. Ensuing this recommendation, numerous schemes, called the location-based, distance -based and counter-based were derived.

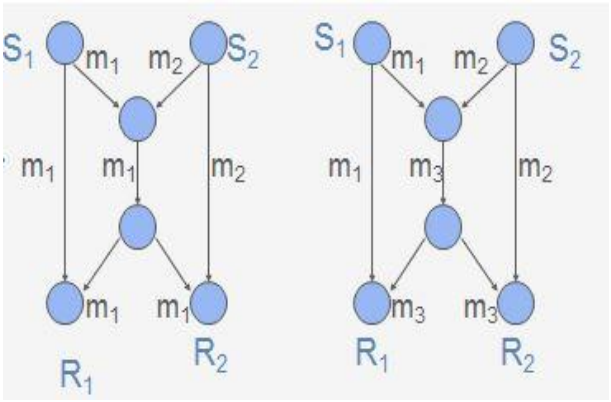

Figure 1.2 Butterfly Network; Source S_1 and S_2 multicast m_1 and m_2 to both receivers

1.3 The Challenges

To build a practical protocol that delivers the above benefits, we need to address a few challenges.

1. **How Many Packets to Send:** In traditional best path routing, a node keeps sending a packet until the nexthop receives it or until it gives up. With opportunistic routing however, there is no particular nexthop; all nodes closer to the destination than the current transmitter can participate in forwarding the packet. How many transmissions are sufficient to ensure that at least one node closer to the destination has received the packet?

2. **Stop and Purge:** With network coding, routers send linear combinations of the packets. Once the destination has heard enough such coded packets, it decodes and

retrieves the file. We need to stop the sender as soon as the destination has received the transfer and purge the related data from the forwarders.

3. **Efficient Coding:** Network coding optimizes for better utilization of the wireless medium, but coding requires the routers to multiply and add the data bytes in the packets. We need efficient coding and decoding strategies to prevent routers' CPU from becoming a bottleneck.

1.4 Previous Solutions

Already proposed several heuristics to reduce rebroadcasts are:

1. **Probabilistic scheme :** Rebroadcast the packet with the randomly chosen probability
2. **Counter-based scheme :** Rebroadcast if the number of received duplicate packets is less than a threshold
3. **Distance-based scheme :** Uses the relative distance between hosts to make the decision
4. **Location-based scheme :** Based on pre-acquired location information of neighbors
5. **Cluster-based scheme :** Only cluster heads and gateways forward again

Network coding can be ordered into 3 primary classes relying upon the sort of combinations; which are: Inter-session NC Intra- session NC, & Joint Inter & Intra Session NC [25]. Inter Session NC can decrease the no. of transfers when the packets from distinctive source are network- coded. We code the packets from a similar source; we are doing intra-session NC.

Using directional antennas, the transmission can be performed only in selected sectors. Therefore, by reducing the total number of transmission sectors of the forwarding nodes in the network, the effect of broadcast storm can be alleviated. This is illustrated using table 1.2 and 1.3 for network sample illustrated in figure 1.3

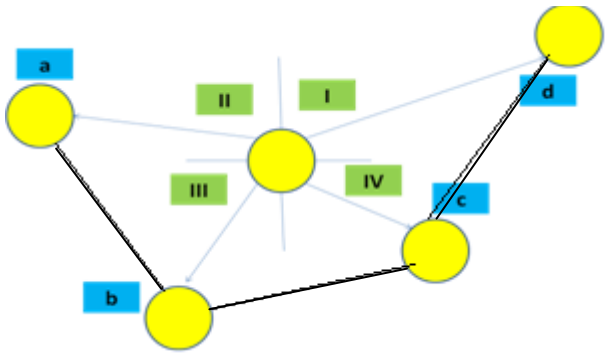

Figure 1.3: A sample network

Table 1.2
Neighbour reception table of node e

Neighbor reception	A	B	C	D
a	1	1	0	0
b	1	1	1	0
c	0	1	1	1
d	0	0	1	1
e	1	1	1	1

Table 1.3
Transmission table of node e using coding and directional antennas

Transmission	P_1	P_2
I	1	1
II	1	1
III	0	1
IV	1	0

With the help of directional antennas, the transmission range of e can be divided into K sectors (K is 4 in this Figure 1.3). P1 need not to be transmitted in sector III. P2 need not to be transmitted in sector IV. Traditional broadcasting where e transmits all four messages omnidirectionally, costs 16. Broadcasting with network coding costs 8. The broadcast with network coding and directional antennas costs 6.

Kruskal's algorithm also finds the minimum cost spanning tree of a graph by adding edges one-by-one.

Kruskal's algorithm:

```
enqueue edges of G in a queue in increasing order of cost.
T = ϕ ;
while(queue is not empty){
  dequeue an edge e;
  if(e does not create a cycle with edges in T)
     add e to T;
}
return T;
```

Prim's algorithm finds a minimum cost spanning tree by selecting edges from the graph one-by-one as follows:

It starts with a tree, T, consisting of the starting vertex, x. Then, it adds the shortest edge emanating from x that connects T to the rest of the graph. It then moves to the added vertex and repeats the process.

Prim's algorithm:

Consider a graph G=(V, E);
Let T be a tree consisting of only the starting vertex **x;**
while (T has fewer than IVI vertices)
{
    find a smallest edge connecting T to G-T;
    add it to T;
}

Figure 1.4 shows the illustration for finding all possible set of spanning tree for a given graph which is further used as a subgraph.

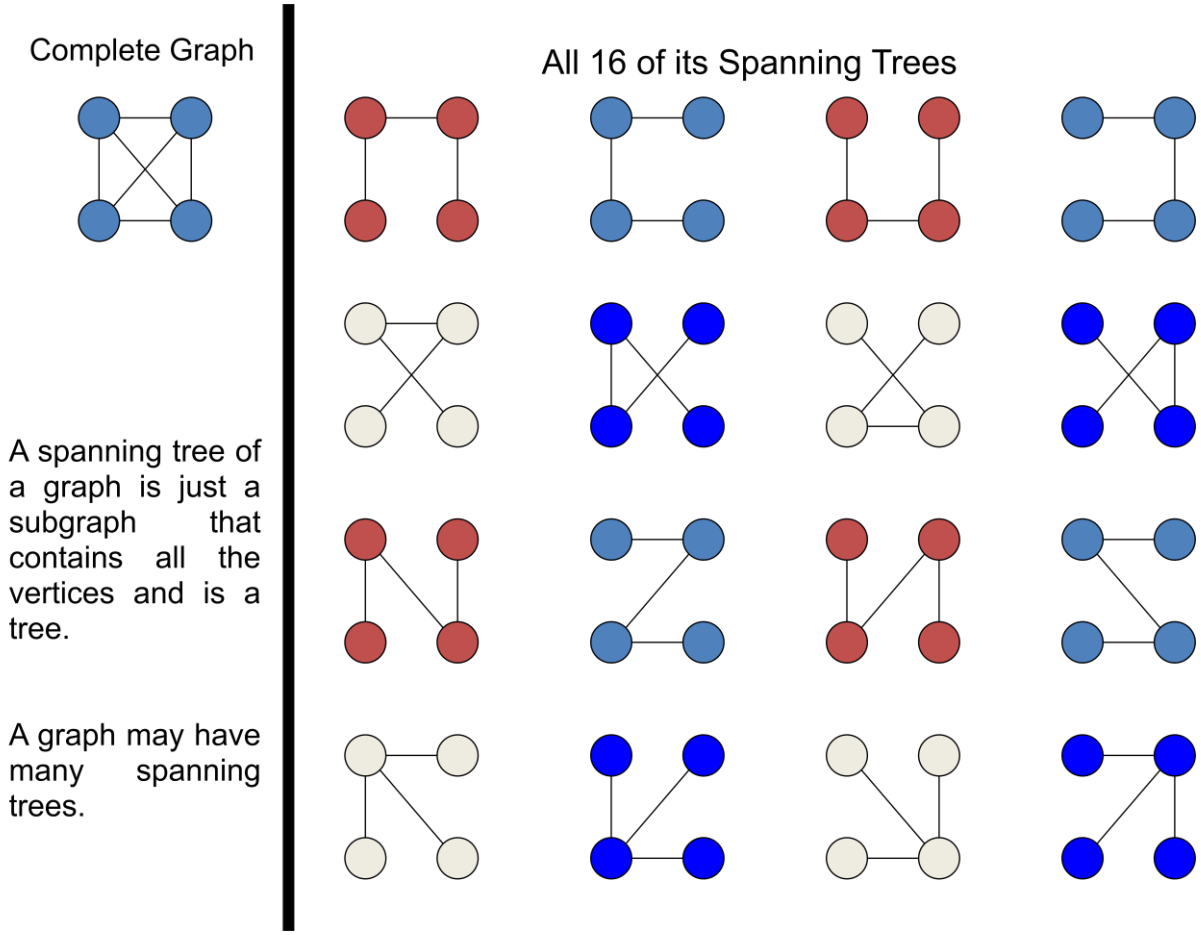
Complete Graph
All 16 of its Spanning Trees
A spanning tree of a graph is just a subgraph that contains all the vertices and is a tree.
A graph may have many spanning trees.

Figure 1.4 Illustration for finding all possible set of spanning tree for a given graph

1.5 Design Principles

1. To fabricate the Network Coding plan, we need to settle on a couple of structure choices. In the first place, we structure our Network Coding plan around the guideline of never deferring packets. At the point when the remote channel is accessible, the hub takes the bundle at the leader of its yield line, checks which

different packets in the line might be encoded with this packet, XORs those packets together, and communicates the XORed form.

2. Second, offer XORing parcels of similar lengths, in light of the fact that XORing smaller bundles with larger ones decreases transmission bandwidth savings.

3. Third, Searching for proper packets to Network Coding is productive because of the support of virtual lines.

4. At last, we need to guarantee that each neighbor to whom a Network Coded packet is going has a high likelihood of unraveling its native packet.

2. GLOBAL NETWORK INFORMATION NETWORK CODING

In General, once a flooding data packet is received by a node then it elects whether or not to relay it to its neighbor. The Neighbor topology primarily Approach to escape the broadcast redundancy in MANET's. We here determine the minimum no. of forwarding node set which forms a minimum connected dominating set. It could be a set of nodes if each node is either within the set or the neighbor is in this set. The task is to pick out tiny set of forwarding nodes within the deficiency of global network information.

2.1 Approaches 1: Global Network Information based Probability captured Network Coding Approach

Here, we have proposed an algorithm which will consider Global Network Information and Probability of transmission of a node along with Network Coding to decide forwarding nodes.

2.1.1. Proposed Model

The main task of the proposed algorithm is to identify the nodes which will perform forwarding of the network coded packets and at the same time the no. of such kind of nodes has to be get reduced and how to perform this based on local information that to be without consulting with rest of the nodes.

Figure 2.1 shows the elimination of node E and F from the broadcast list of node A since they got the similar data bit or message from neighbor B and C, respectively. Such kind of nodes needs to be eliminated out to reduce the no. of forwarding nodes.

Table 2.1 shows the simulation environment parameters which are considered.

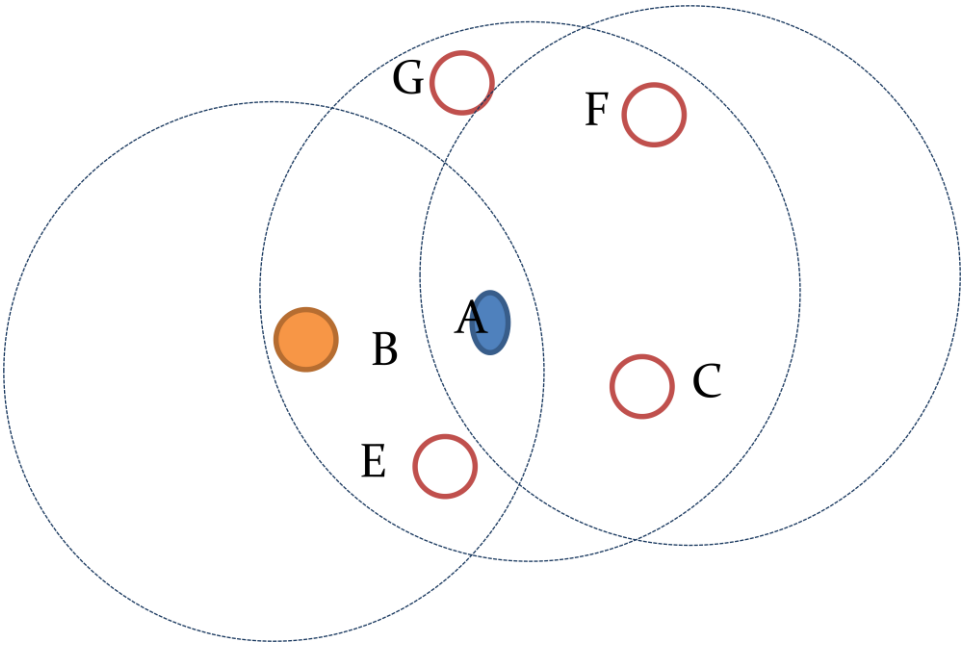

Figure 2.1: Elimination of neighbor node E and F from the list of Node A.

Table 2.1
Simulation Environment

Simulation Parameter	**Value**
Tool Used	NS - 2
Topological size	900m * 900m
Range of Transmission (m)	300
Bandwidth (Mbps)	2.5
Speed (m/s) – Max	5.2
Speed (m/s) – Min	1.2
Pause time	0 s
Packet Rate (packets/sec)	4
Packet size (bytes)	512
No. of CBR Connection	15
Traffic Type	Constant Bit Rate
Interface Queue Length	60

Figure 2.2 is considered for the explanation purpose of our algorithm.
In Figure 2.2,

s = Sender (Node 6);

r = Receiver;

N (r) = neighbors of node v;

N(N(r)) = neighbors of N (r);

U(s , r) = 2-hop neighbor set;

F (s , r) is the forward node list.

Table 2.2 shows the 1-hop and 2-hop neighbor-hood information. It appears to be normal to allow a node with additional no. of neighbors transmit prior, as the substantial number of secured nodes will more probable render other booked retransmissions repetitive.

Table 2.2
1-hop and 2-hop neighbor-hood information for Figure 2.2 network

R	**N(r)**	**N(N(r))**
12	12,11,8	12,11,10,8,7,4
11	12,11,10,7	12,11,10,9,8,7,6,4,2
10	11,10,9	12,11,10,9,7,6,5
9	10,9,6,5	11,10,9,7,6,5,2,1
8	12,8,7,4	12,11,8,7,6,4,3,2
7	11,8,7,6,4,2	12,11,10,9,8,7,6,5,4,3,2,1
6	9,7,6,5,2	11,10,9,8,7,6,5,4,3,2,1
5	9,6,5,1	10,9,7,6,5,2,1
4	8,7,4,3	12,11,8,7,6,4,3,2
3	4,3,2	8,7,6,4,3,2,1
2	7,6,3,2,1	11,9,8,7,6,5,4,3,2,1
1	5,2,1	9,7,6,5,3,2,1

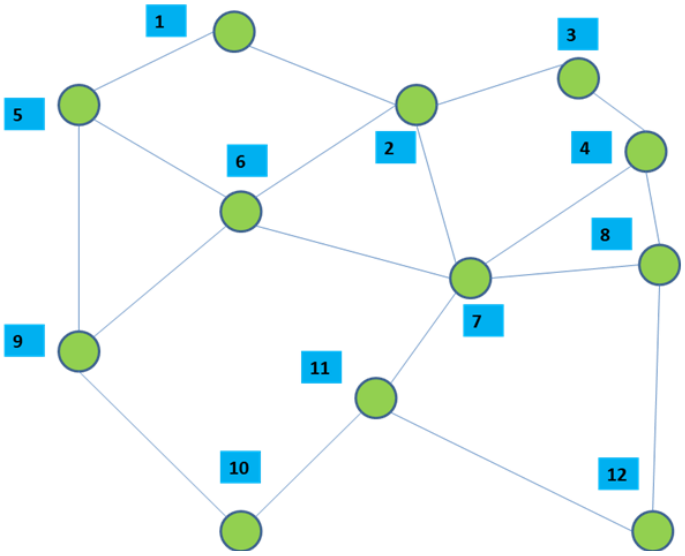

Figure 2.2: Network of twelve nodes with node 6 as source node

Proposed BSP-NC-ALGO-1:

1. U (s, r) = N (N (r)) – N (s) – N (r)
2. B (s, r) = N (r) – N (s)
3. Node r determines F (s, r). (F can be selected from B to cover U).

Table 2.3
Result of Proposed BSP-NC-ALGO-1

S	R	U	B	F
Φ	6	11,10,8,4,3,1	9,7,5,2	9,2,7
6	7	12,10,3,1	11,8,4	4,11
6	2	11,8,4	3,1	3
6	9	11,1	10	10
7	11	9	12,10	10
7	4	12	3	[ ]
2	3	8	4	4
9	10	12,7	11	11

Result of Proposed BSP-NC-ALGO-1 clearly shows that the total numbers of forward nodes are 8 while total no. of nodes is 12.

Proposed BSP-NC-ALGO-2:

1. P (s, r) = N (N (s) ∩ N (r))
2. U (s, r) = N (N(r)) – N (s) – N (r) − P (s, r)
3. B (s, r) = N (r) − N(s)
4. Node r determines F (s, r). (F can be selected from B to cover U)

Table 2.4
Result of Proposed BSP-NC-ALGO-2

s	**R**	**P**	**U**	**B**	**F**
φ	6	Φ	11,10,8,4,3,1	9,7,5,2	9,2,7
6	7	7,6,3,1	12,10	11,8,4	11
6	2	11,8,6,4,2	Φ	3,1	[ ]
6	9	9,6,1	11	10	10
7	11	Φ	9	12,10	10
9	10	Φ	12,7	11	11

Result of Proposed BSP-NC-ALGO-2 clearly shows that the total numbers of forward nodes are 6 while total no. of nodes is 12.

Proposed BSP-NC-ALGO-3:

1. U (s, r) = N (N (r)) – N (N (s))
2. B (s, r) = N (r) – N (s)
3. Node r determines F(s, r). (F can be selected from B to cover U)

Table 2.5
Result of Proposed BSP-NC-ALGO-3

S	R	U	B	**F**
Φ	6	11,10,8,4,3,1	9,7,5,2	9,2,7
6	7	12	11,8,4	8
6	2	Φ	3,1	[ ]
6	9	Φ	10	[ ]
7	8	Φ	12	[ ]

Result of Proposed BSP-NC-ALGO-3 clearly shows that the total numbers of forward nodes are 5 while total no. of nodes is 12.

Further Steps for proposed BSP-NC-ALGO-1, 2, 3:

1. For source node, take out 1-Hop and 2-Hop Neighbors
2. Take out Forwarding Nodes by using algo 1, algo 2 and algo 3 as illustrated earlier
3. Apply network coding concept to algo 1, algo 2 and algo 3.
    a) For each node, FIFO queue of packets is created to forward packets.
    b) Keep a track of hash table also.
    c) The probability of each neighbor having that packet in output queue is shown by the table.

4. Select each forwarding node from forward list of algo 1, algo 2 and algo 3. If forward probability of each packet is >= 0.5 then perform XOR of all packets and then broadcast.

2.1.2. Experiment and Result

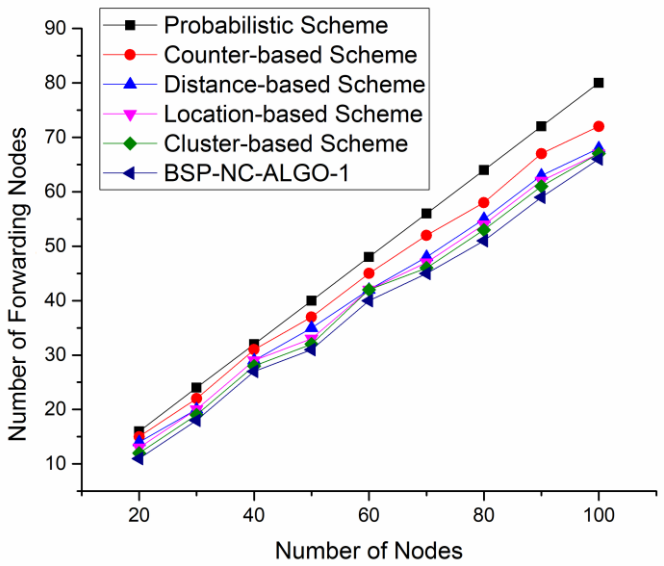

Figure 2.3 Comparison (Probabilistic Scheme, Counter-based Scheme, Distance-based Scheme, Location-based Scheme, luster-based Scheme, & BSP-NC-ALGO-1)

Figure 2.3 shows comparison between Probabilistic Scheme, Counter-based Scheme, Distance-based Scheme, Location-based Scheme, luster-based Scheme, & BSP-NC-ALGO-1 when plotted between Number of forwarding bodes for retransmission after Network Coding approach and Number of actual nodes of transmission.

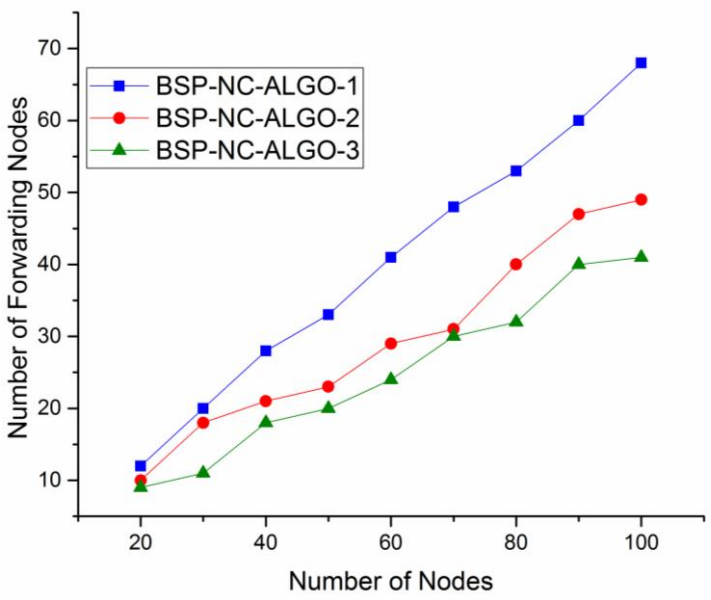

Figure 2.4 Comparison (transmitter range as 20 using BSP-NC-ALGO 1-3)

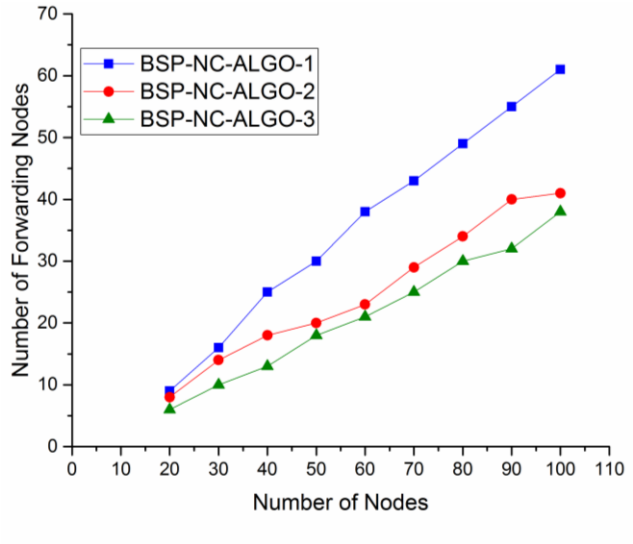

Figure 2.5 comparison (Average Node degree as 10 using BSP-NC-ALGO 1 -3)

Figure 2.4 and 2.5 shows comparison between proposed BSP-NC-ALGO 1, 2 &3 when plotted between Number of forwarding bodes for retransmission after Network Coding approach and Number of actual nodes of transmission while keeping different statistics of transmitter range as 20 and average node degree as 10 simultaneously.

2.2 Approach 2: Traffic Degree and Bandwidth based Network Coding Approach

Here, we have proposed an algorithm which will consider incoming traffic degree and outgoing traffic degree of a node along with sum of input and output bandwidth of a node decide forwarding nodes.

2.2.1. Proposed Model

Proposed BSP-NC-ALGO-4 :: For (all nodes i =1 to M), calculate from step 1-7

1. $\mathbf{D_{in}(i)} = {}_{j=1}\Sigma^{M}\, conn_{ji}$
2. $\mathbf{D_{out}(i)} = {}_{j=1}\Sigma^{M}\, conn_{ij}$
3. $\mathbf{S_{in}(i)} = {}_{j=1}\Sigma^{M}\, bw_{ji}$
4. $\mathbf{S_{out}(i)} = {}_{j=1}\Sigma^{M}\, bw_{ij}$
5. $\mathbf{N_{in}(i) = D_{in}(i) * (S_{in}(i) / D_{in}(i))^{p}}$
6. $\mathbf{N_{out}(i) = D_{out}(i) * (S_{out}(i) / D_{out}(i))^{p}}$
7. $\mathbf{N(i) = N_{out}(i) * (N_{in}(i) / N_{out}(i))^{p}}$
8. Choose that node "i" for which the value of nucleus N(i) is *maximum* and apply network coding.

Where

$\mathbf{D_{in}(i)}$ represents incoming traffic degree of network node

$\mathbf{D_{out}(i)}$ represents outgoing traffic degree of network node

$\mathbf{Conn_{ji}}$ **,** $\mathbf{conn_{ij}}$ **=** 1 if connection is present ,else = 0

$\mathbf{S_{in}(i)}$ **&** $\mathbf{S_{out}(i)}$ represents the dominance, sum of input and output link bandwidth (bw)

"**$N_{in}(i)$** " represents the incoming nucleus of a node,

"**$N_{out}(i)$** " represents the outgoing nucleus of a node,

"**N(i)** " represents the nucleus of a node,

"P" represents the probability of a node of packet transmission.

2.2.2. Experiment and Result

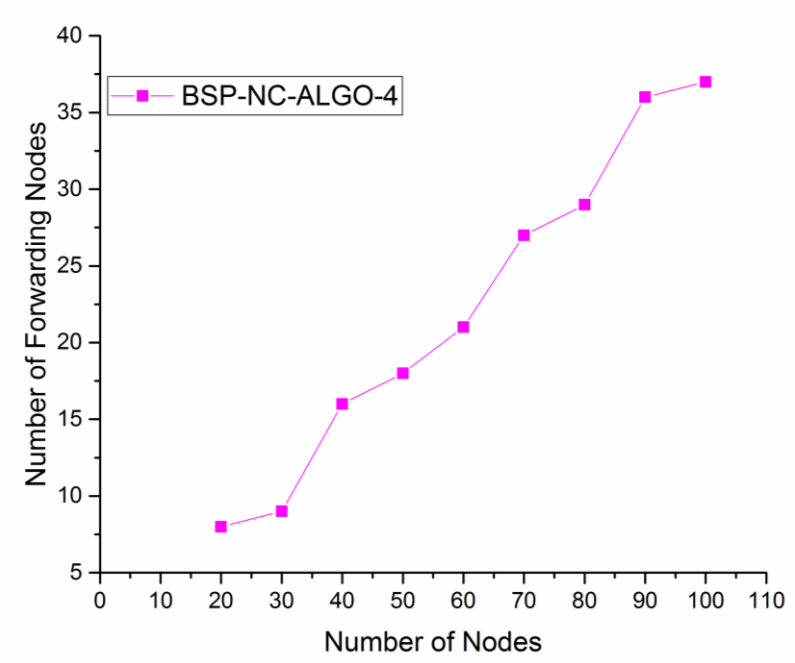

Figure 2.6 Result based on keeping transmitter range as 20 using BSP-NC-ALGO-4

Figure 2.7 shows comparison between proposed BSP-NC-ALGO 1, 2, 3 & 4 when plotted between Number of forwarding bodes for retransmission after Network Coding approach and Number of actual nodes of transmission while keeping transmitter range as 20.

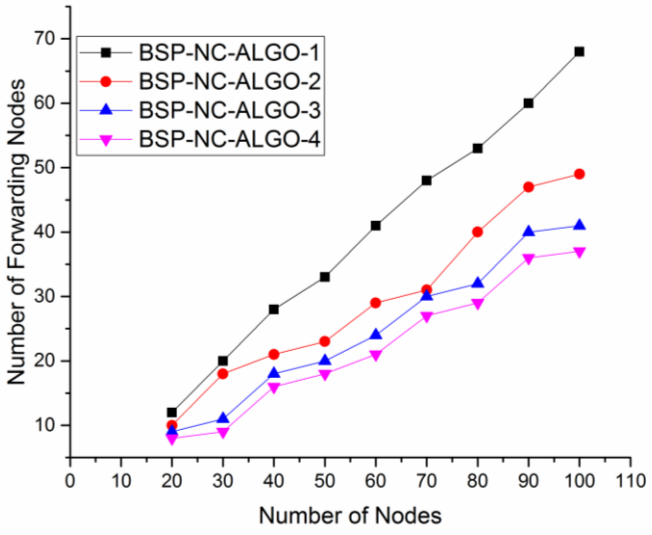

Figure 2.7 Comparison (BSP-NC-ALGO- 1 - 4)

2.3 Summary and Discussion

Broadcasting in a MANET has generally extraordinary attributes from that in different networks. It could bring about mindful redundancy, collision and contention. Network coding may affect the outline of the design of new networking and information dissemination protocols. The simulation clearly demonstrates that Algorithm 3 requires minimum no. of nodes when integrated along with the concept of network coding in contrast with other two algorithm (Algo 1 & Algo 2) to reduce no. of forwarding nodes for reducing the effect of broadcast storm problem.

Algorithm 4 works on the concept of incoming traffic degree, outgoing traffic degree of network node, sum of input and output link bandwidth of a node of packet transmission. Algorithm 4 requires minimum no. of nodes in contrast to Algorithm 1, 2 and 3 thus performs better.

3. ADDRESS BIT VECTOR AND SET PARTITION THEORY BASED NETWORK CODING

Our network coded algorithm is a NC convention which accomplishes reliability for information gathering application for remote systems. We accept a two-level system with static courses where every hub conveys its packet to a relay node. Thus, this transfer will convey got packets to the sink. We accept systems where transfers, as a rule, are sufficiently far that they don't catch each other. This will include complexity while accomplishing reliability since caught packets by transfers are major in recouping packets.. In our algorithm NC is performed utilizing the XOR operation. Just, when a data packet is received, the hubs will XOR the substance with at least one packet which is accessible in its cradle. Then, resulting packet is sent to the next hop.

In this section we are proposing with a specific end goal to recognize the packets which were XORed, address of every packet is incorporated into the header of the coded message. Be that as it may, this represents a vast overhead on the span of the coded packets which at times can surpass the measure of the payload. To conquer this issue, our algorithm uses bit addresses where it alludes to the identity of the actual originating packets.

3.1. Approach 1: Address Bit Vector Integrated Network Coding

For an illustration as appeared in Fig. 3.1, consider that relay node got packet P_3 and packet P_4 and needs to network-code them together.

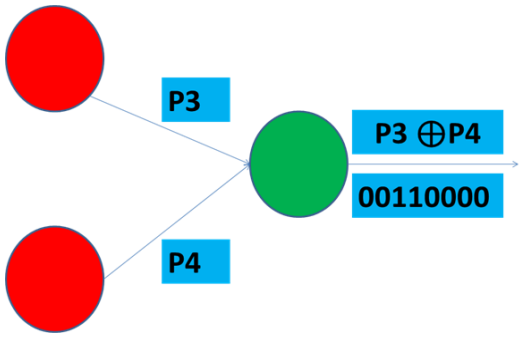

Figure 3.1: Binary coding of addresses

When Network coding is performed using XOR operation, Set the relating bits that allude to the address of the originating packets to bit value as '1'. For example shown in figure 3.1, bit 3 & 4 will be set to show that the coded packets contains data from hub 3 & hub 4. A bigger piece vector will be utilized in bigger systems.

Algorithm Design

Principle thought behind our algorithm is to infuse enough excess to accomplish unwavering quality without exhausting the power hold of the remote hubs. Our algorithm design indicates 3 actions for hubs, each with an different assignment. In Figure 3.2, hubs at the primary level will send recorded information and can code packets. Relay nodes are in charge of decoding, coding & sending packets. Sink hub is in charge of uncoding packets.

For every new uncoded bundle got, the hubs will XOR its substance with its content with its list of uncoded parcels each one in turn. Just un-coded packets are coded, as demonstrated in figure 3.2 where hubs don't action decoding. For instance, if hub 2 catches parcels P1 & P3, it will along these lines send, to the relay hub, P2 ⊕ P1 and afterward P3 ⊕ P1 ⊕ P2. Additionally, for every parcel, this will set the corresponding bit addresses in the headers. Normally, in the primary packet the hub will set bit location 2 and 1, and in the second bundle it will set piece area 3, 2, & 1.

Proposed BSP-NC-ALGO-5: Network Coding at Nodes

a) if !Network_Coding() then
b) Hold_up for sink packet()
c) else
d) Begin Network_Coding()
e) Timer.begin()
f) Bit_Address = 1<<a
g) P_a.Network_coded=0
h) send_Packet(P_a)
i) end if
j) if Hear_Packet(P_b) then
k) if Heard_Packet_Is_Uncoded(P_b) then
l) $P_a = P_a$ XOR P_b
m) P_a.Coded=1
n) Address = 1<<a | 1<<b
o) Forward(P_a)
p) end if
q) if Timer.fired() then
r) end Timer()
s) end if

After gathering of packets (single or combined) at the relay hubs, parcels are ordered whether they are uncoded or coded. The relay hub will interpret these bundles in planning for sending as appeared in Algorithm 2. The point of the interpreting calculation is to achieve all parcels in their un-coded unique format. Decoding calculation functions as follows: The initial step of translating begins with un-coded bundles. It will emphasize over all un-coded bundles each one in turn. The calculation checks if the un-coded parcels exist in coded bundles. It is finished by a checking if the bit address at the area of the address of the un-coded bundle is set to 1.

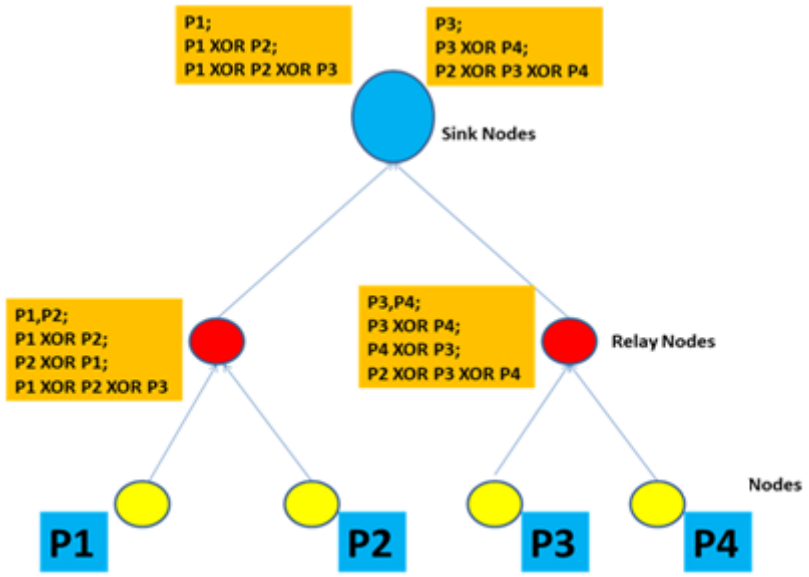

Figure 3.2: Wireless network

Proposed BSP-NC-ALGO-5: Decoding at Relay Nodes

a) Hold_up for Start();
b) if Heard_Packet(P_a) then
c) if P_a.uncoded == 1 then
d) Uncoded_Buffer.add(P_a)
e) else
f) Coded_Buffer.add(P_a)
g) end if
h) end if
i) while(All_Packets_Uncoded() | m<n)
j) for a=1:size.Uncoded_Buffer
k) for b=1:size.Coded_Buffer
l) P = Codded_Bufferb)>
m) if Cardinality(P_a) >1 then
n) if Uncoded_Buffer(a).exists then
o) P = P XOR Uncoded_Buffer(a)
p) P.Address = P.Address XOR Uncoded_Buffer(a). Address
q) if Sum_up(P) ==1 then
r) Uncoded_Buffer.add(P)
s) end if
t) end if
u) end if
v) end for
w) end for
x) end while

First: P_1
Second: P_1 XOR P_2
Third: P_1 XOR P_2 XOR P_3
Fourth: P_4 XOR P_3 XOR P_2 XOR P_1

At last the sink will get the parcels from all transfers and will play out the interpreting calculation depicted before.

3.1.1. Experiment and Results

To confirm the accuracy of the proposed work, we have tested the above said algorithm on a systems comprise of a solitary sink, 5 relay nodes and 20 nodes as indicated in Figure 3.3.

For every emphasis, we varied the quantity of packet loss from zero percent to almost hundred percent of the first parcels sent by hubs. The packet loss was randomized.

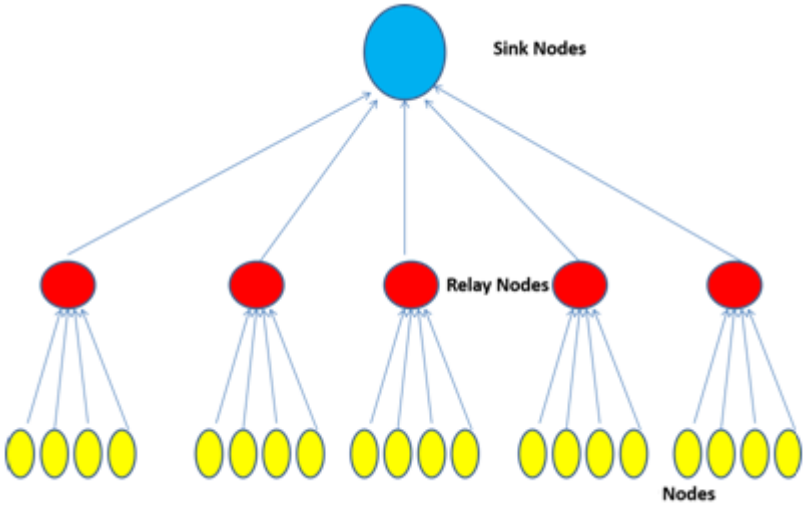

Figure 3.3: Network with Twenty nodes

The execution weakens in light of the fact that the quantity of parcels sent is less since the quantity of hubs per relay node increased. In this manner, when the quantity of hubs increment in a similar hop, the quantity of overheard parcels is lessened and thusly the quantity of sent packets. Our algorithm just sends the original un-coded packet and coded packets from nearby neighbors.
To exhibit the impact of including more hubs, we reenacted a system of 8 hubs and 4 transfers. Then, we quantified the quantity of packet sent and the level of redundancy. The redundancy is figured as for original parcels sent. For a case, an excess of two hundred percent implies that the quantity of bundles sent is double the quantity of unique parcels.

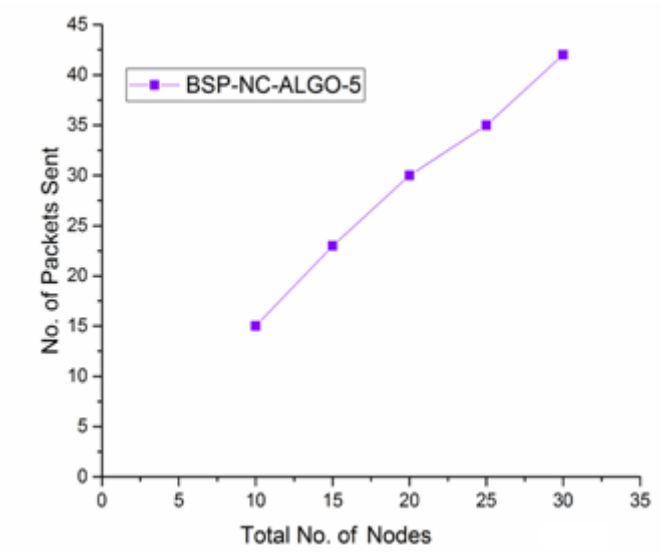

Figure 3.4 Total no. of packets sent with respect to no. of nodes

Considering Figures 3.4 and 3.5, quantity of hubs is set as 10, 15, 20, 25 and 30 while keeping network with neighboring hops to one, the repetition is ~1.4.

Figure 3.5 shows the plot between Total no. of nodes vs % of packets sent. Figure 3.6 shows plot between Numbers of forwarding bodes for Network Coding approach and Number of actual nodes.

Figure 3.7 shows comparison between proposed BSP-NC-ALGO 1, 2, 3, 4 & 5 when plotted between Numbers of forwarding bodes and Number for retransmission after Network Coding approach and Number of actual nodes.

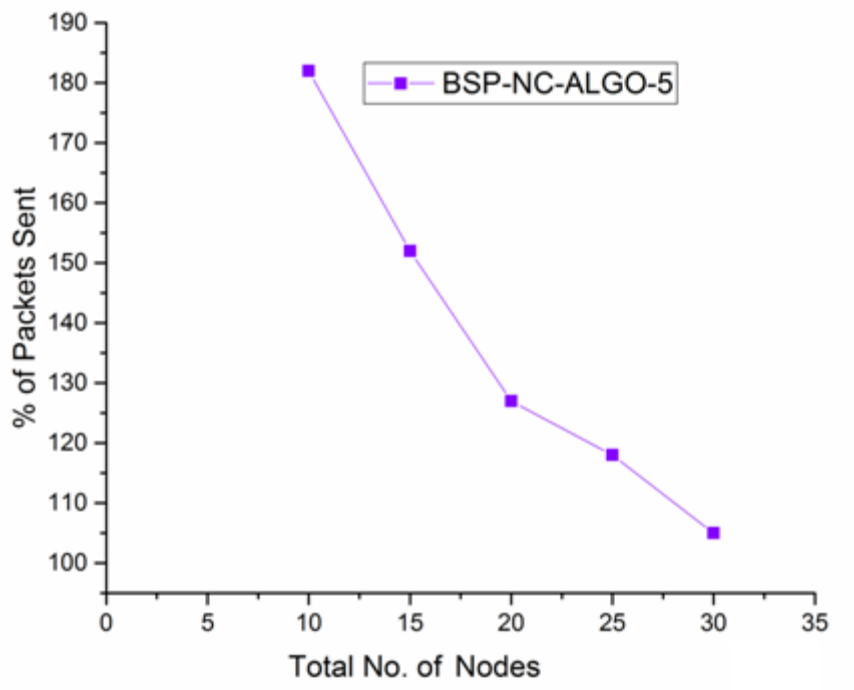

Figure 3.5 Total no. of packets sent with respect to no. of nodes

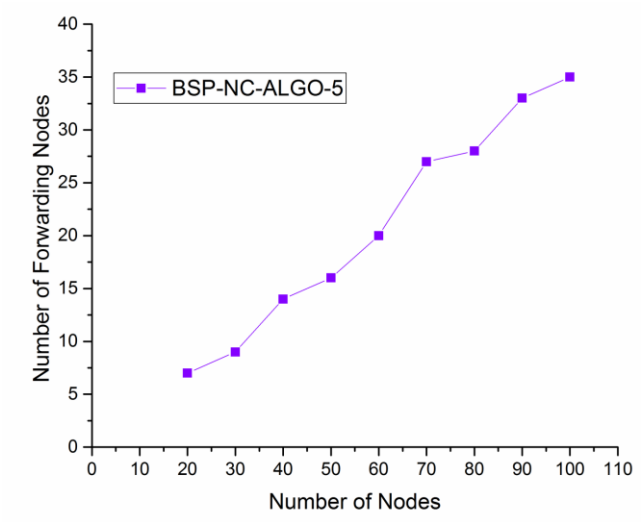

Figure 3.6 Result using BSP-NC-ALGO-5

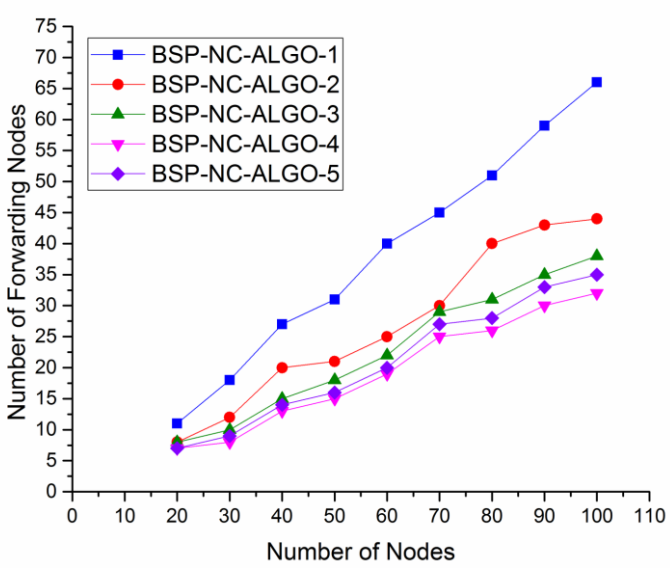

Figure 3.7 Comparison (BSP-NC-ALGO 1 - 5)

3.2. Approach 2: SET PARTITION INTEGRATED NETWORK CODING

We have proposed an algorithm that simply uses the concept of SET theory along with Network Coding to reduce the No. of Forwarding nodes for retransmission.

3.2.1. Proposed algorithm

Proposed algorithm distinguishes and comprises nodes based on the fact of bundles of different network coded packets based on SET Theory along with Network Coding to reduce the No. of Forwarding nodes for retransmission in contrast to actual no. of nodes.

Consider Fig. 3.8 with 7 leaves (1,2,3,4,10,11,12) and 5 intermediate nodes (5,6,7,8,9). Assume that nodes 1, 10 act as sources S_1, S_2 and send probes p_1 = [10], p_2 = [01] respectively. All other leaves act as receivers.

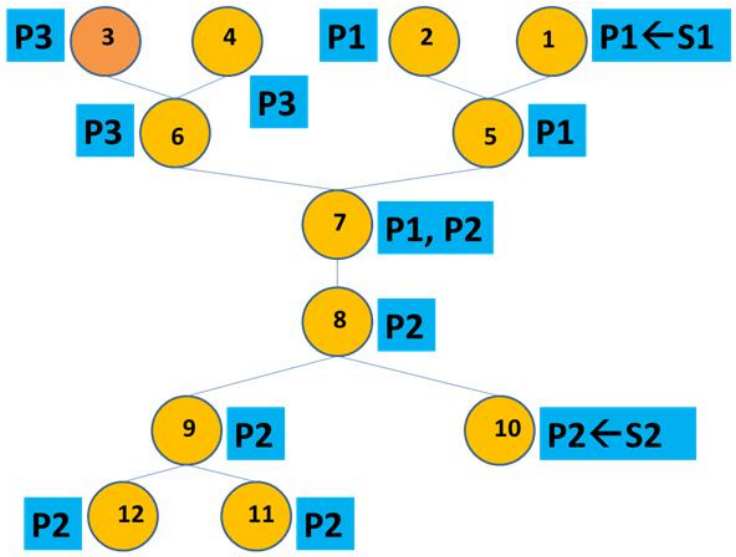

Figure 3.8 Network with 7 leaf nodes

Proposed BSP-NC-ALGO-6:

Iteration 1: Consider the set **SET** which comprise of **all leaf nodes**.

1. **Two leaf nodes** start working as **sources S_1, S_2**; sending **probes P_1, P_2** respectively.

   All other leaves **S - {S_1; S_2} act as receivers.**
2. **partition SET** (into **SET_1 U SET_2 U SET_3**) as follows.

   a) **SET_1 contains S_1 and all receivers that receive p_1.**
   b) **SET_2 contains S_2 and all receivers that receive p_2.**
   c) **SET_3 contains all receivers that receive p_3 = p1 ⊕ p2.**
3. If **$SET_3 \neq \phi$**, replace the original graph with the three sets SET_1, SET_2, SET_3.
4. If **$SET_3 = \phi$**,, replace the original graph with two sets SET_1, SET_2, connected through a single edge.

Iteration i:

1. Consider any 1 previously identified SET_i and repeat.
2. As done earlier, two leaves in SET_i act as sources S_1 and S_2 and all remaining nodes in SET_i act as receivers.
3. Node A_i that connects SET_i to the network will act as an aggregate receiver; whatever packet is received by A_i will be multicasted and received by all leaves in SET that are not in SET_i

4. Repeat the exact same procedure as in iteration 1 to reveal the structure of SET_i . Connect the component to the network depending on what packet is received by A_i.

5. Remove vertices of degree two this way and so on.

Illustration of Algorithm

Intermediate node 5 receives p_1 and forwards it to leaf 2 and to node 7.Similarly, node 8 receives p_2 and forwards it to node 9 (which in turn forwards it to leaves 11,12) and to node 7. Probe packets p_1 and p_2 arrive at node 7, which adds them, creates the packet $p_3 = p_1 \oplus p_2 = [11]$, and forwards p_3 to node 6, which in turn forwards it to leaves 3, 4. At the end, leaf 2 receives p_1, leaves 11,12 receive p_2 and leaves 3, 4 receive $p_3 = p_1 \oplus p_2$.

Thus, the leaves of the tree can be partitioned into three sets:
SET_1 = {1, 2}; leaf nodes having packet p_1 and source S_1
SET_2 = {10,11,12} ; leaf nodes having packet p_2 and source S_2
SET_3 = {3, 4} ; leaf nodes having packet p_3

3.2.1. Experiment and results

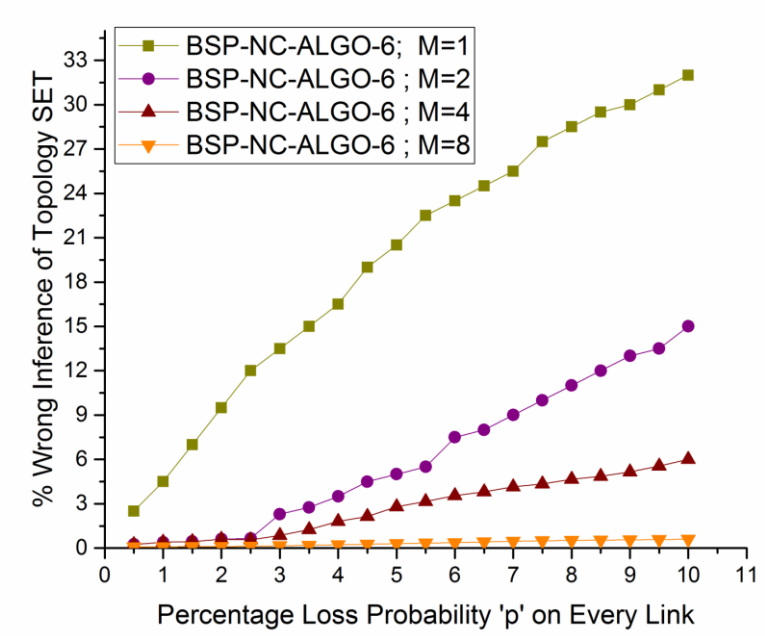

Figure 3.9 Percentage Wrong Inference of topology SET vs Percentage Loss Probability 'p' on Every Link for i=2 for different values of Probes "M"

Figure 3.9 shows the plot between % loss Probability 'P on every link vs % wrong inference of topology SET after 2 iterations (i=2) and for different values of Probes with value 1,2,4 and 8.

Figure 3.10 shows comparison between proposed BSP-NC-ALGO 1,2,3, 4 5 and 6 when plotted between Number of forwarding bodes for retransmission after Network Coding approach and Number of actual nodes of transmission.

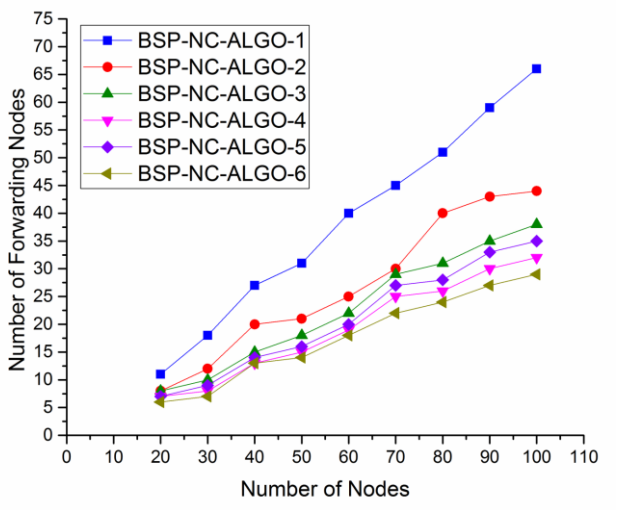

Figure 3.10 Comparisons (BSP-NC-ALGO 1 - 6)

3.3 Summary and Discussion

The algorithm uses the XOR operator to network-code packets. Besides, this utilizes bit addresses to which brings down the measure of bytes sent per packet. Also, utilizing bit addresses to help in recognizing the quantity of packets incorporated into each coded packet and permits to effortlessly distinguishing which packet are incorporated into the coded message. Testbeds were led on three distinct systems where the quantity of nodes is expanded. SET Partition theory based algorithm when integrated with Network Coding approach distinguishes and comprises nodes based on the fact of bundles of different network coded reduces the No. of Forwarding nodes for retransmission in contrast to actual no. of nodes.

4. NETWORK CODING INTEGRATED AODV SCHEME

AODV protocol is integrated with Network Coding (NC) approach to make maximum utilization of both the theories. AODV has following main procedures.

Path Discovery
This process takes off when a source node 'S' wants to exchange some packets with another node for which it has zero routing knowledge [19]. Each node maintains two different counters- a node sequence number and a broadcast id. The source node 'S' begins path discovery by broadcasting a route request (RREQ) packet to its neighbors.

A Route Request has the following fields:

<source_address; source_sequence_no.; broadcast_id; destination_address; dest_sequence_no.; hop_count >
When a source node 'S' issues a new Route Request, the broadcast_id is incremented. When a node receives a Route Request, and if it has got a Route Request with the same *broadcast id* and source address in advance, it drops the duplicate Route Request [19].

Reverse Path Setup

To establish the reverse path, a node maintains the record of the address of the neighbor from which it has received the initial copy of the Route Request. These reverse path route logs are retained for at least enough time for the Route Request to traverse the network [20].

Forward Path Setup

At the point when the Route Request comes at a node that has a way to beneficiaries, it figures out if the root is current by looking at the destination sequence number. If sequence number in RREQ is higher than that maintained by the moderate node, the moderate node must not utilize its recorded path.

Route Table Management

For every entry, active neighbor's address is recorded through which packets for the given destination are received. A neighbor is understood as if it forwards at least one packet for that destination.

In the advised algorithm, using AODV from a known graph G, paths between each pair of nodes are determined. Then for every node, the count of reiteration of each of its nexthops for dissimilar destinations are recorded. Next hops are chosen for which the count is maximum. For these next hops of a node, the edges connecting them with the node are retained as they were in the original graph, while others are deleted. Thus, a subgraph of the original graph G' is created. Network coding algorithm is applied over this subgraph.

4.1 Approach 1: Network Coding Integrated AODV Scheme

Proposed BSP-NC-ALGO-7 (G)

1. By using AODV algorithm [20], routes are found out for every pair of nodes.
2. **For every** node 'p' in the original graph G **do**
for Node 'q'=1 to n (No. of nodes) **do**
for Node 'r'=1 to n **do**
m.nexthops ← next_hop for source=q, destination=r
Counts ← reiterations for each Nexthop
end for
end for
p.Max = max(p.Counts), nexthop for which count = max is recorded and stored in p.Neighbors
end for
3. **For** Nodes p=1 to n **do**
for q=1 to n **do**
if q ∈ i.neighbors **then**
matrix(p,q)=1
else
matrix(p,q)=0
endif
end for
end for
4. Graph G' is drawn keeping only connection between nodes i and j if matrix(p,q)=1.
5. Network Coding algorithm is implemented on graph G', a subgraph of G.

4.1.2 Experiments and Results

Maximum allowed degree of a node is taken as 5 for the simulation purpose and algorithm is tested over 50 no. of nodes.

Figure 4.1 clearly represents the plot between Average No. of Transmissions per Node Vs. Forwarding Factor in case of both schemes i.e. old network coding scheme and new AODV integrated Network coding scheme i.e. Proposed BSP-NC-ALGO-7.

Figure 4.2 shows plot between Number of Forwarding Nodes for network coding i.e. retransmission vs Actual number of nodes.

Figure 4.3 shows comparison between proposed BSP-NC-ALGO 1,2,3,4,5,6 and 7 when plotted between Number of forwarding bodes for retransmission after Network Coding approach and Number of actual nodes of transmission.

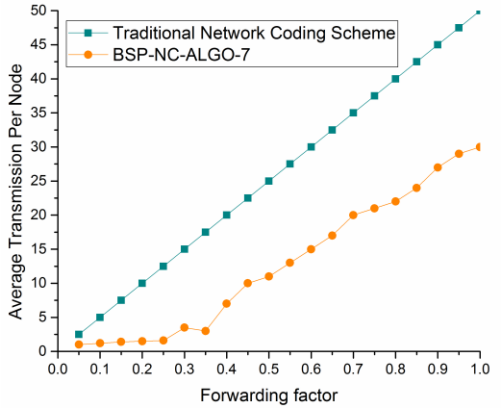

Fig 4.1 Average No. of Transmissions per Node Vs. Forwarding Factor using Traditional Network Coding Scheme and Proposed BSP-NC-ALGO-7

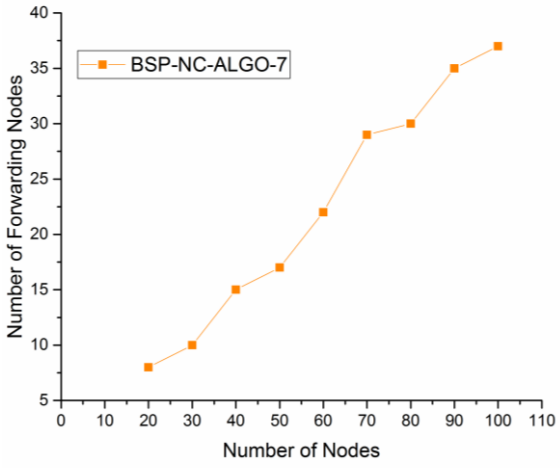

Figure 4.2 Number of forwarding Nodes vs Number of Nodes using Proposed BSP-NC-ALGO-7

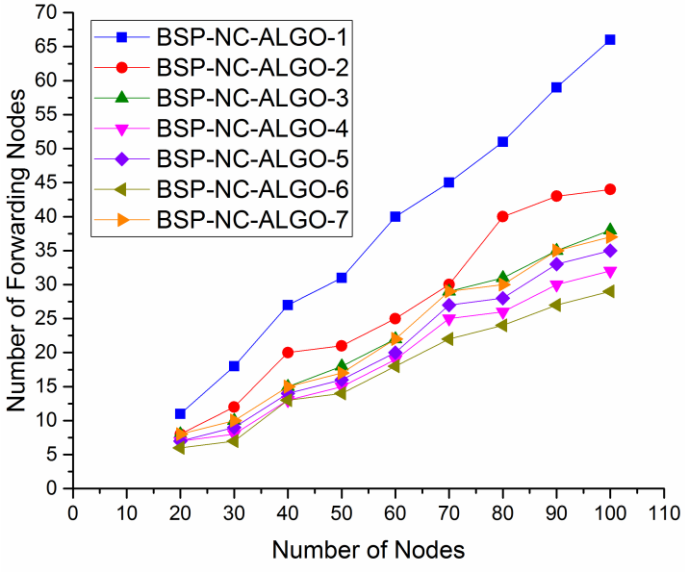

Figure 4.3 Comparisons (BSP-NC-ALGO 1-7)

4.2 Summary and Discussion

From the above discussions, facts and figures, it is clear that On integrating Network coding scheme with the AODV protocol, the algorithm formed is much more energy proficient as compared to the old Network coding scheme since less no. of average transmissions are required per node. The enhancement in the performance of the proposed AODV integrated Network coding scheme over the original Network coding scheme increases with increase in density. Hence a basic alteration of discovering a reduced subgraph from the first original subgraph utilizing AODV routing scheme can enhance the execution of Network Coding to an awesome degree.

4 CONCLUSION

Broadcasting in a MANET has generally extraordinary attributes from that in different networks. It could bring redundancy, collision and contention. Network coding may affect the outline of the design of new networking and information dissemination protocols. The simulation clearly demonstrates that considering neighborhood information when integrated along with the concept of network coding requires minimum no. of forwarding nodes in contrast with other algorithms.

Algorithm proposed on the concept of incoming traffic degree, outgoing traffic degree of network node, sum of input and output link bandwidth of a node of packet transmission requires minimum no. of forwarding nodes in contrast with global network information based algorithm and thus performs better.

Besides, these algorithms utilize bit addresses to which brings down the measure of bytes sent per packet. Also, utilizing bit addresses to help in recognizing the quantity of packets incorporated into each coded packet and permits to effortlessly distinguishing which packet are incorporated into the coded message.

SET Partition theory based algorithm when integrated with Network Coding approach distinguishes and comprises nodes based on the fact of bundles of different network coded reduces the No. of Forwarding nodes for retransmission in contrast to actual no. of nodes.

The enhancement in the performance of the proposed AODV integrated Network coding scheme over the original Network coding scheme increases with increase in density. Hence a basic alteration of discovering a reduced subgraph from the first original subgraph utilizing AODV routing scheme can enhance the execution of Network Coding to an awesome degree.

We have learnt innumerable noteworthy lessons while taking a shot at this usage. Especially, it pays to be opportunistic. Rather than seeking to accomplish transmission capacity, nodes will utilize local information to detect coding opportunities and will endeavor them. The productivity of broadcasting gives off an impression of being straight forwardly related to the construction of a connected dominating set of minimal size. Future research includes applying these proposed algorithm to make network coded routing more scalable. A challenge in our view is how to control a lot of overhead where our proposed algorithm are promising and avoiding any overhead. We might attempt to ensure collision free transmission with nearly higher probability.

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